NDCEE

National Defense Center for Energy and Environment

DoD Executive Agent

Office of the Assistant Secretary of the Army (Installations and Environment)

Evaluation of a Low Temperature Cure Powder Coating

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13th Annual Joint Services Environmental Management Conference & Exhibition, May 5-8, 2008

The NDCEE is operated by: CTC Concurrent Technologies Corporation

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
MAR 2008		**00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Evaluation of a Low Temperature Cure Powder Coating	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **National Defense Center for Energy and Environment (NDCEE),Concurrent Technologies Corporation,100 CTC Drive,Johnstown,PA,15904**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**31**	

Overview

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Introduction

- The National Defense Center for Energy and Environment (NDCEE)'s mission is to support DoD sustainability and readiness through:
  - Transition of environmentally acceptable materials and processes to defense industrial activities and private industry
  - Training that supports the use of new, environmentally acceptable technologies
  - Applied research and development, where appropriate, to transition new technologies.

Background

- Low Temperature Cure Powder Coating (LTCPC) developed under Strategic Environmental Research and Development Program (SERDP) Project PP-1268
- SERDP PP-1268 completed by GE Global Research, Crosslink Powder Coatings, Inc., and several Department of Defense facilities
- Developed to address deficiencies of conventional powder coating materials
- Powder coating needed for temperature sensitive substrates such as Aluminum 2024 (Al 2024-T3)

Background (cont'd)

- Dem/Val activities were performed under the Commercialization of Technologies to Lower Defense Costs (CT/LDC) Program executed by the NDCEE
- Dem/Val designed to supplement ongoing Environmental Security Technology Certification Program (ESTCP) efforts

LTCPC Dem/Val Team

- LTCPC Dem/Val team included:
  - NDCEE (project management, laboratory services)
  - Fleet Readiness Center Southeast (FRC Southeast) (in-kind services and materials)
  - Crosslink Powder Coatings, Inc (in-kind services)
  - ESTCP Team (technical review and outreach)

LTCPC Properties

- Coating cures at 120°C (250°F) in 30 minutes
- Applied with conventional powder coating equipment
- Coating does not require a primer
- No VOCs or HAPs

Approach

Evaluate the LTCPC against the baseline liquid coating by performing the following tests:

- Impact Resistance ASTM D3170-03 (Gravelometer)
- Corrosive Environments
  - ASTM B117 (Salt Spray Fog),
  - SAE J2334 (Cyclic Corrosion),
  - ASTM G155 (Weatherometer)
- Fluid Resistance MIL-PRF-85285D
  - Hydraulic Fluid
  - Jet Fuel (JP-5)
  - Lubricating Oil

Pre-Test Activities

Panel Pre-Treatment

- 27 – 4”x6”x1/4” Al 2024-T3 panels were chromate conversion coated by NDCEE per MIL-DTL-5514F Type 1 Class A
- Reserved for LTCPC

- 27 – 4”x6”x1/4” Al 2024-T3 panels were chromate conversion coated by FRC Southeast per MIL-DTL-5514F Type 1 Class A
- Reserved for baseline coating

Pre-Test Activities

- Oven Scan Profile for LTCPC panels
- Determines time required to heat a batch of panels to cure temperature of 250 °F (15 minutes)
- 15 minutes added to cure time of 30 minutes

Coating Processes

- Baseline coating performed by FRC Southeast using a standard air assisted spray gun
- Cured for several days at room temperature
- Coating thickness 2-4 mils

- LTCPC performed by Crosslink Powder Coatings, Inc. using a Gema® powder application gun
- Coating thickness 2-4 mils

Testing Activities

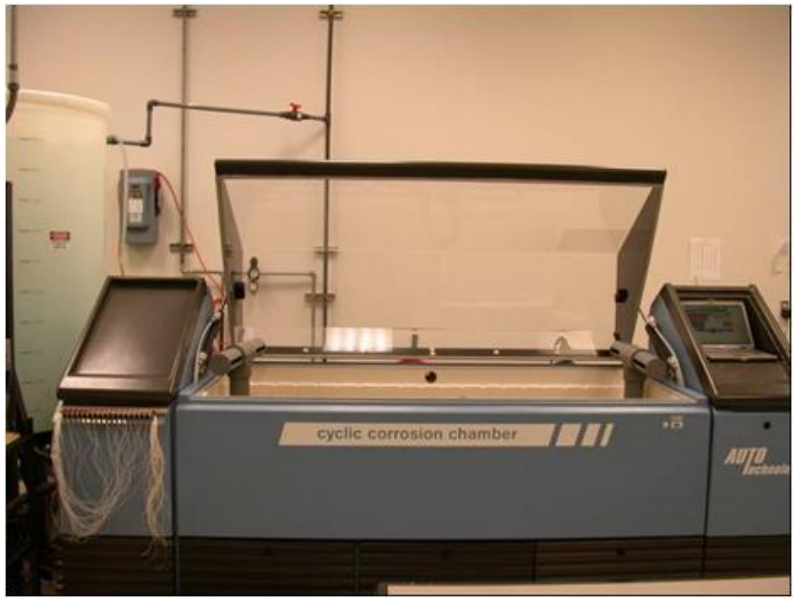
- Coating Evaluation
  - Atlas VIEEW™ Digital Image Analyzer in accordance with the Test for Chip Resistance of Surface Coatings (SAE J400)
  - Illuminates the surface of the panels and quantifies the contrasting areas of damaged coating and undamaged coating

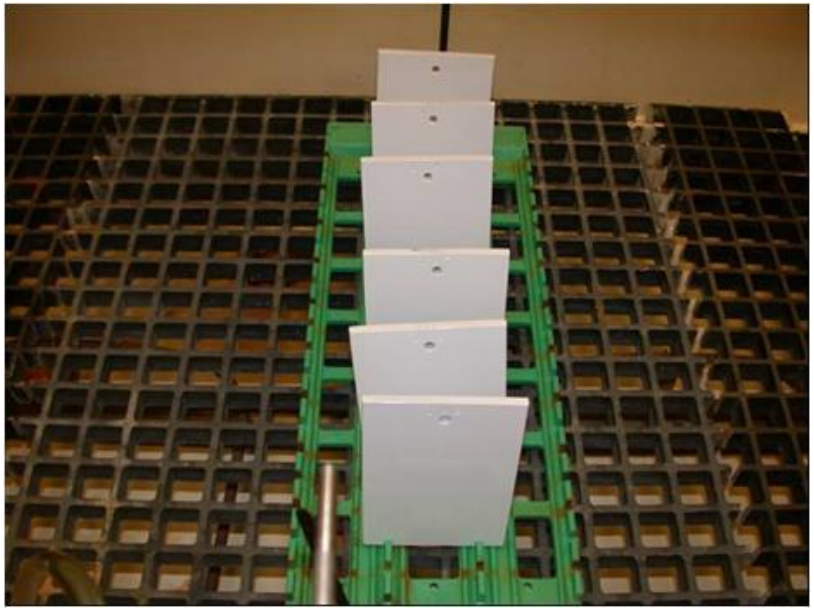
Testing Activities (cont.)

- Gravelometer Testing per ASTM D3170
  - Standard size gravel (i.e. approximately 3/8”–5/8” diameter) at a 45º angle of impact
  - Panels gravelometered before and after exposure to corrosive environments and fluid resistance tests

Testing Activities (cont.)

- SAE J2334 Cyclic Corrosion Test - 120 cycles (120 days)
- ASTM B117 Salt Spray Fog Test – 2,000 hours



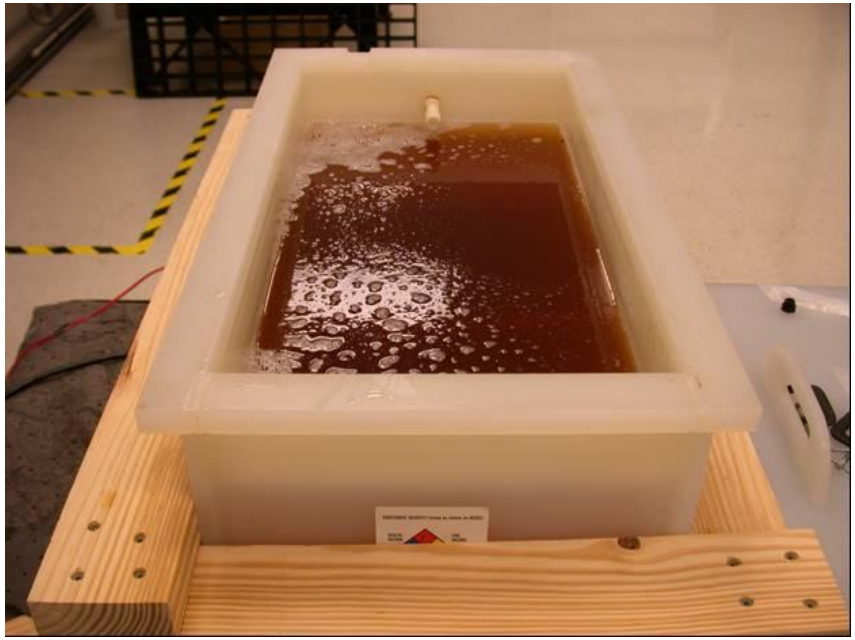


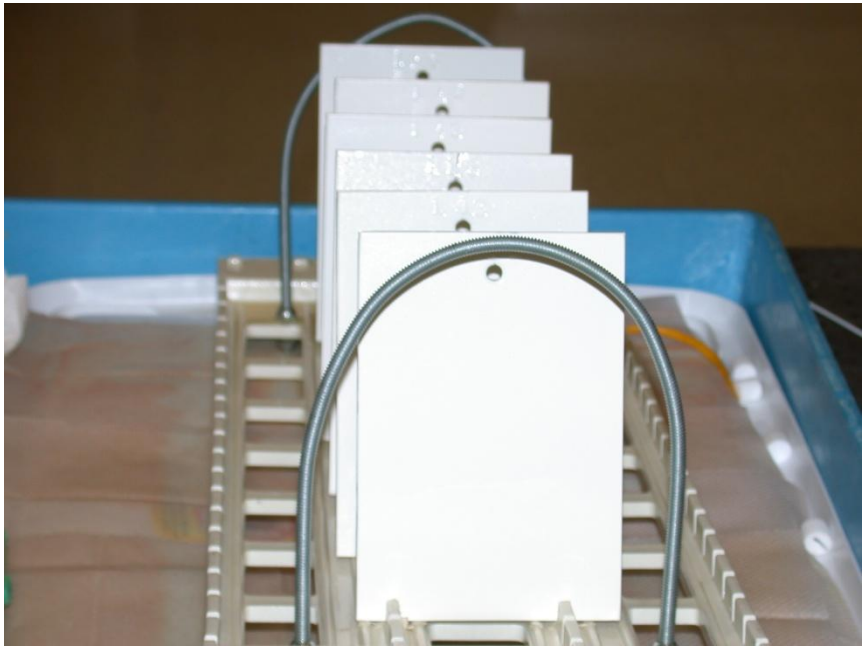
Testing Activities (cont.)

- ASTM G155 Weatherometer Test – 1,000 hours

Testing Activities (cont.)

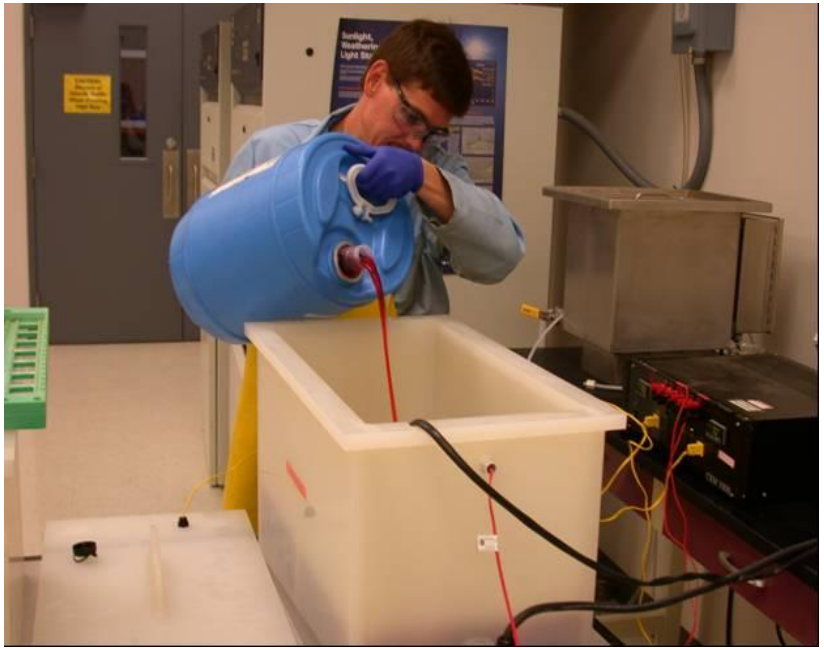
- Lubricating Oil – Royco 899
  - 24 hours at 121°C ± 3 °C (250 ºF ± 5 °F)

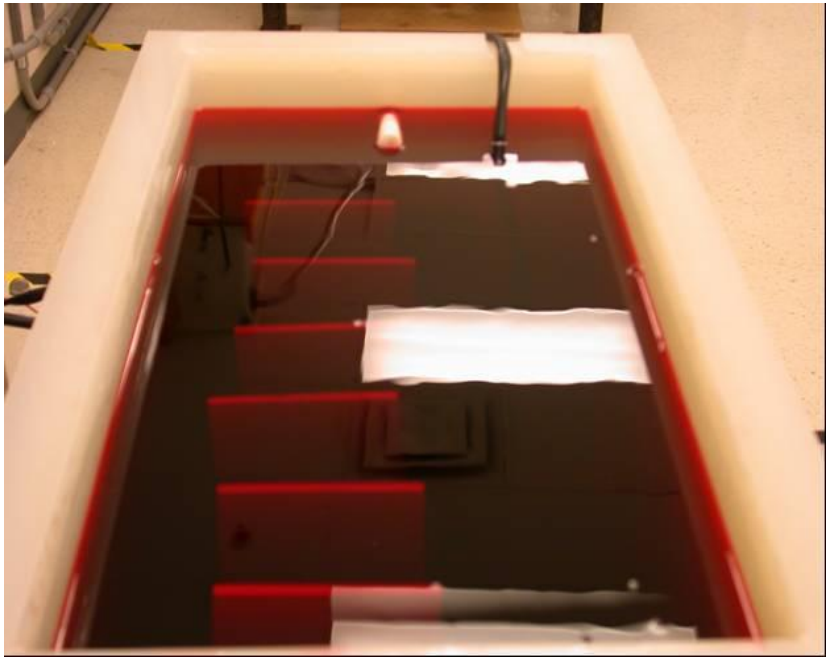




Testing Activities (cont.)

- Hydraulic Fluid – Royco 782
  - 24 hours at 66°C ± 3 °C (151 ºF ± 5 °F)





Testing Activities (cont.)

- JP-5 Jet Fuel
  - 7 days at room temperature

Results

- Coating Evaluation
  - SAE J400, Chip Rating System

Rating Number	Number of Chips	Rating Number	Number of Chips
10	0	4	50-74
9	1	3	75-99
8	2-4	2	100-149
7	5-9	1	150-250
6	10-24	0	>250
5	25-49		

Rating Letter	Size of Chips
A	< 1 mm (<approximately 0.03 in)
B	1-3 mm (approximately 0.03 – 0.12 in)
C	3-6 mm (approximately 0.12 – 0.25 in)
D	> 6 mm (>approximately 0.25 in)

Results (cont.)

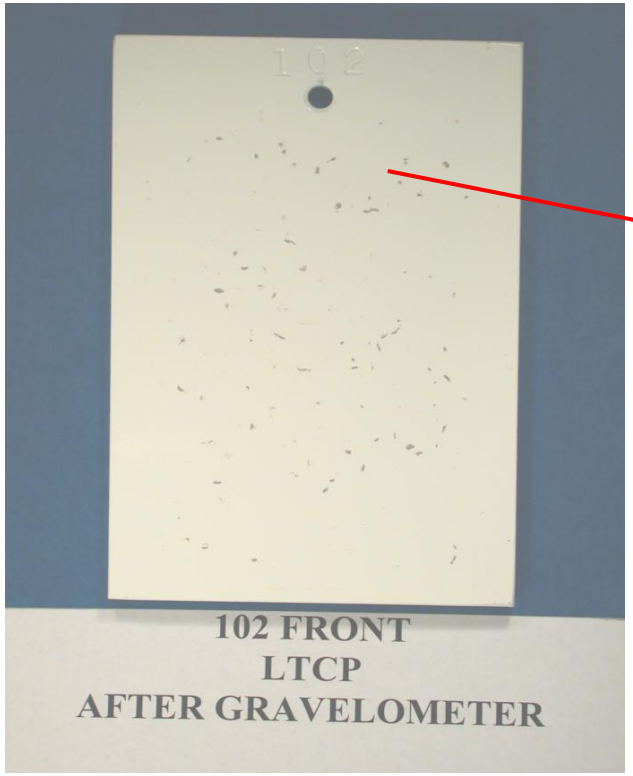
- Example Chip Rating: Initial Gravelometer Test

Panel Coating/Panel #	Damaged Area, %	Chip Rating
Powder Coat, 102	0.61	2A-5B-10C-10D
Powder Coat, 104	0.56	2A-6B-10C-10D
Powder Coat, 108	0.74	2A-5B-10C-10D
Powder Coat, 114	0.71	1A-5B-10C-10D
Avg.	0.65	
Liquid Coating, 127	1.15	1A-4B-10C-10D
Liquid Coating, 128	1.04	1A-5B-10C-10D
Liquid Coating, 129	1.42	1A-4B-10C-10D
Liquid Coating, 130	1.28	1A-4B-10C-10D
Avg.	1.22	

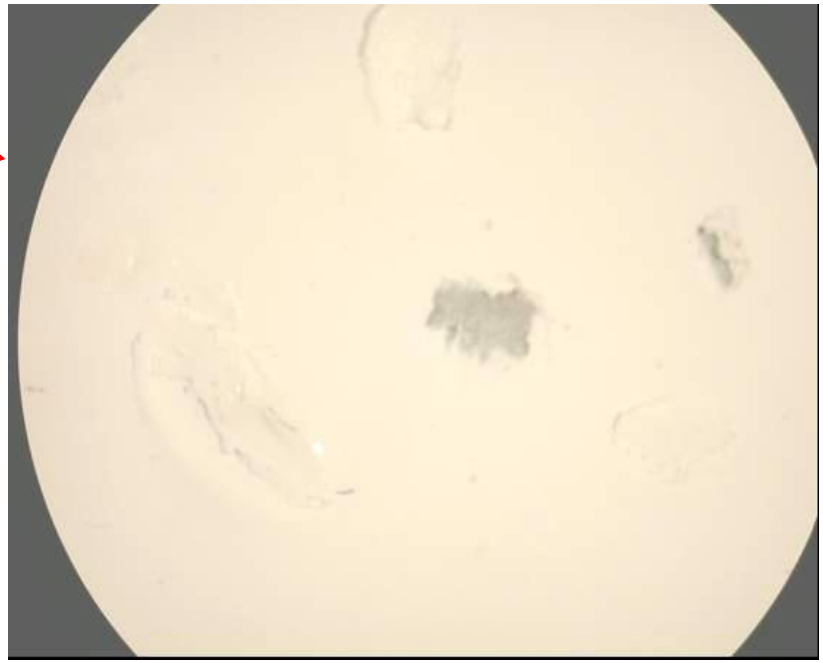
2A	100 -149 Chips	< 1 mm
5B	25-49 Chips	1-3 mm
10C	0 - Chips	3-6 mm
10D	0 - Chips	> 6 mm

Results (cont.)

- Initial Gravelometer Test
  - Notice deformation/divots on the powder coated panel
  - Coating damaged but adheres to substrate

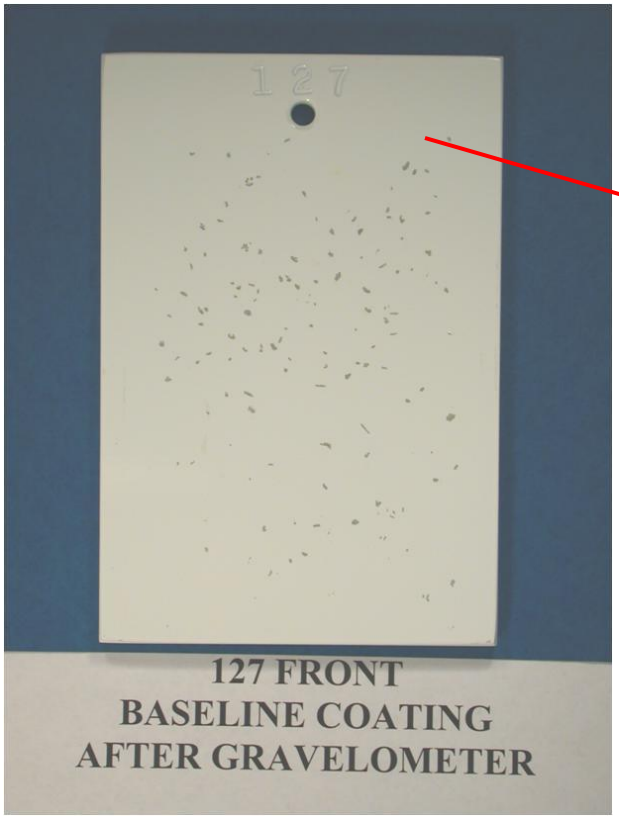


LTCPC panel (10x)

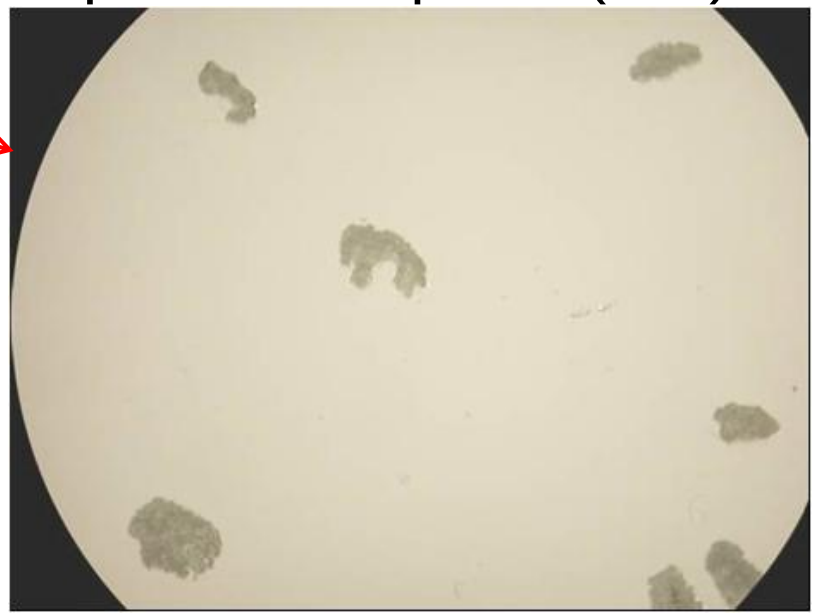


Results (cont.)

- Initial Gravelometer Test
  - Notice chipping on the liquid coated panel
  - Coating damaged, chips do not adhere to substrate



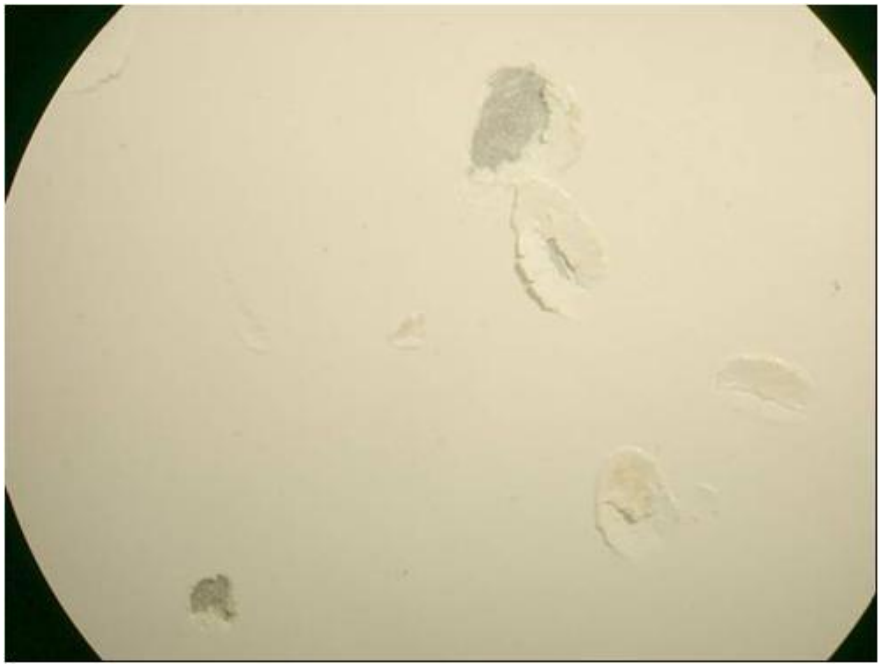
Liquid coated panel (10x)



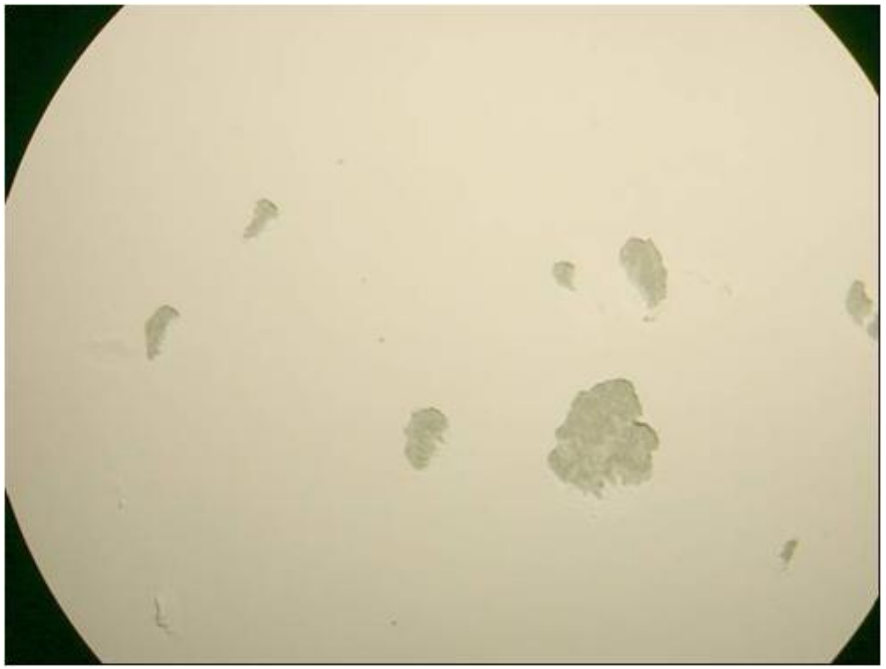
Results (cont.)

- Panels after 1,000 hours exposure in the Weatherometer and subsequent gravelometer treatment

LTCPC panel (10x)



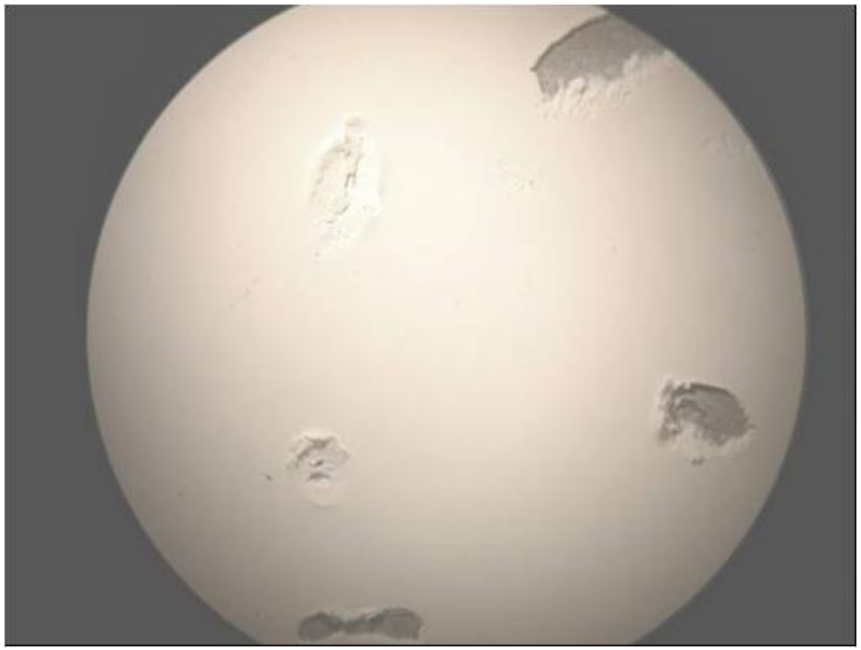
Liquid coated panel (10x)



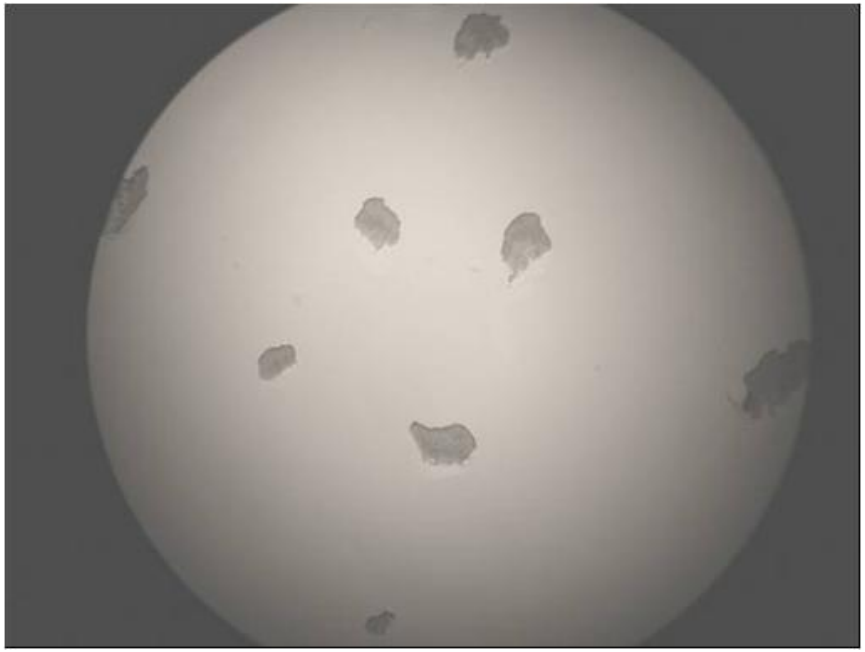
Results (cont.)

- Panels after 24 hours immersion in JP-5 jet fuel and subsequent gravelometer treatment

LTCPC panel (10x)

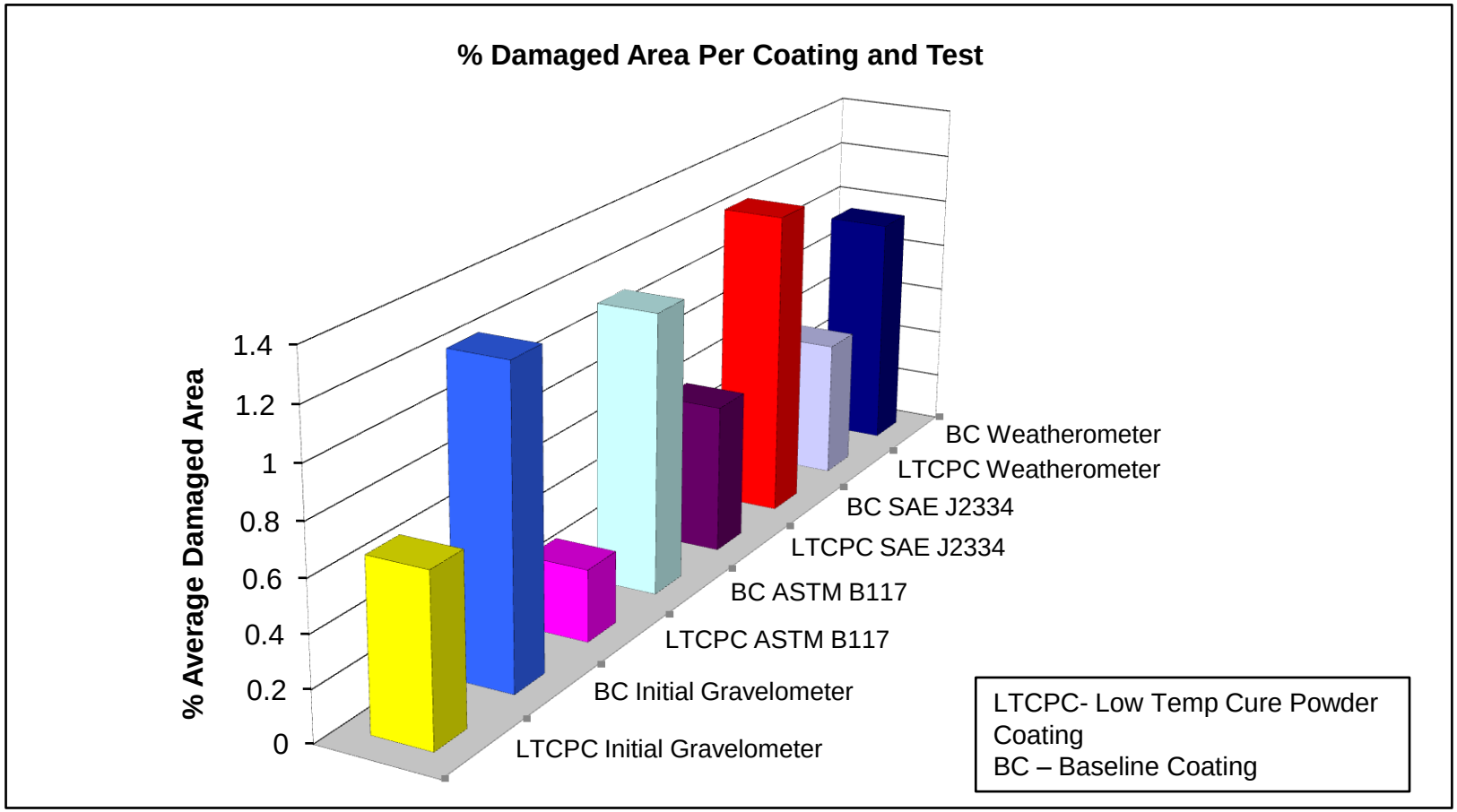


Liquid coated panel (10x)

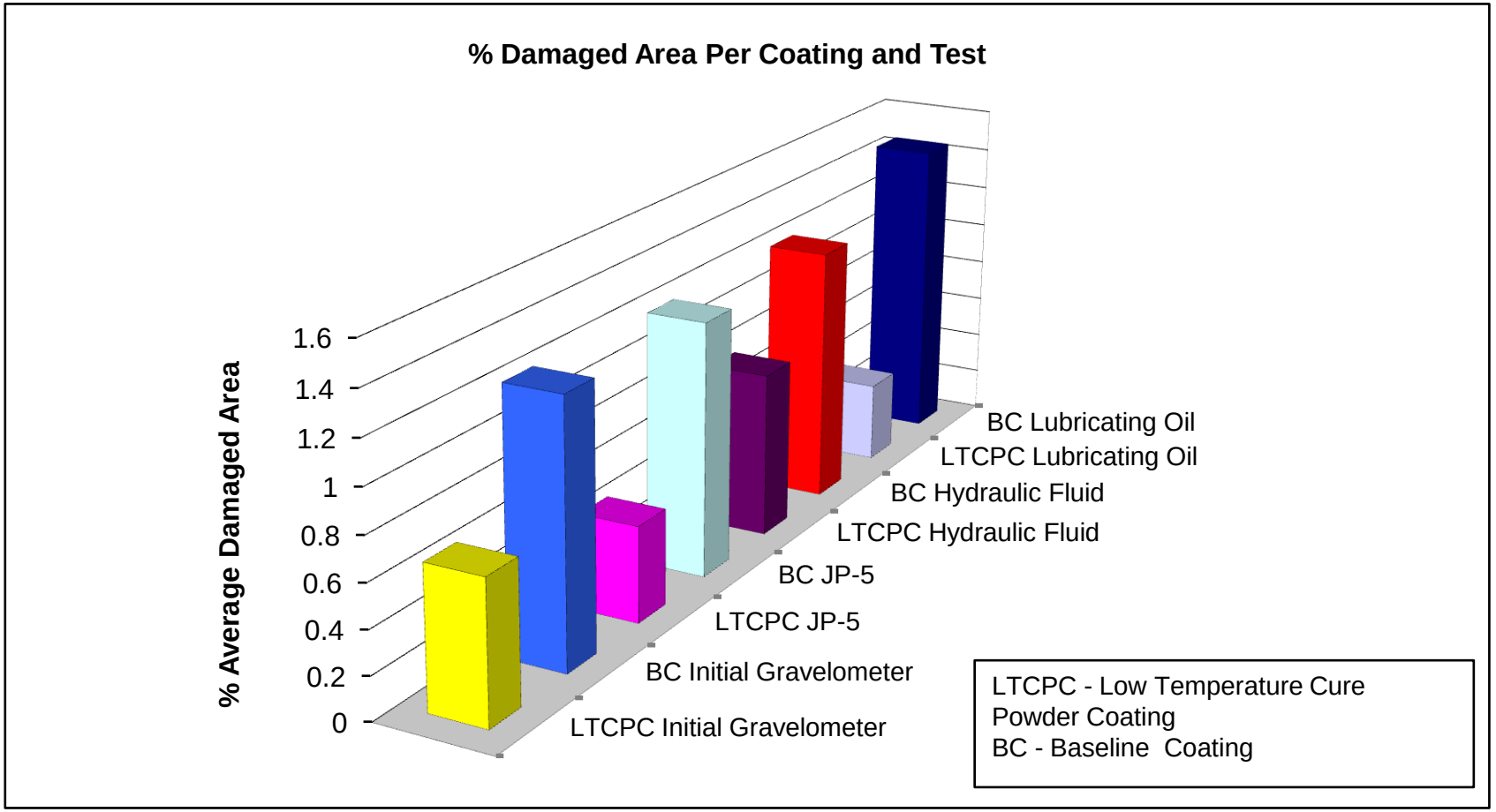


Results (cont.)

- Percent Damaged Area per SAE J400



Results (cont.)



Cost Benefit Analysis

Cost Summary Table

	Baseline (current process)	Alternative 1 (low eqpt cost)	Alternative 2 (high eqpt cost)
Capital Costs			
Labor	$0	$9,600	$9,600
Materials	$0	$0	$0
Equipment	$0	$149,803 [a]	$349,803 [b]
Utilities	$0	$0	$0
EHS	$0	$0	$0
Other	$0	$0	$0
Subtotal	**$0**	**$159,403**	**$359,403**
O&M Costs			
Labor	$918,905/yr	$712,604/yr	$712,604/yr
Materials	$24,626/yr	$8,601/yr	$8,601/yr
Equipment	$0/yr	$10,486/yr	$10,486/yr
Utilities	$0/yr	$38,155/yr	$38,155/yr
EHS	$13,054/yr	$13,343/yr	$13,343/yr
Other	$0/yr	$0/yr	$0/yr
Subtotal	**$956,585/yr**	**$783,190/yr**	**$783,190/yr**

a. Alternative 1 assumes equipment costs are low (excludes design, procurement, installation costs)
b. Alternative 2 assumes equipment costs are high (includes design, procurement, installation costs)

Cost Benefit Analysis (cont.)

Financial Indicators

	Alternative 1 (low equipment cost assumed)			Alternative 2 (high equipment cost assumed)		
Financial Indicator	**5-year**	**10-year**	**15-year**	**5-year**	**10-year**	**15-year**
Net Present Value of Savings	$641,544	$1,342,598	$1,956,218	$436,968	$1,127,270	$1,725,629
Incremental Rate of Return	106%	109%	109%	39%	47%	48%
Discounted Payback Period	0.9 years			2.1 years		

Calculations based on OMB Circular A-94 real interest rate of 2.7% for 15-year study period (revised January 2008)

Conclusions

- LTCPC product performs equal to or better than the baseline coating:
  - Increased Gravelometer impact resistance over the baseline coating
  - Comparable resistance to JP-5 jet fuel, hydraulic fluid, and turbine engine oil
  - Comparable corrosion resistance
  - Shorter curing time
  - Favorable financial indicators suggest a positive cost benefit

Recommended Activities

- Full-scale, life cycle testing of LTCPC should be evaluated on actual military components (e.g., F/A-18 aircraft landing gear, ground support equipment)
- Based on results to date, FRC Southeast should proceed with plans to procure a powder coating booth and other equipment needed to implement LTCPC on components
- Use of low temperature cure powder coat on FRC Southeast parts manufactured from other substrates (e.g., steel) should be evaluated

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This work was funded through the Office of the Assistant Secretary of the Army (Installations and Environment) and conducted under contract W74V8H-04-D-0005 Task 427.